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STERILITY AND FERTILITY IN THE STRAWBERRY[1]

By GEORGE M. DARROW

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SEX TYPES AND STERILITY

In the cultivated strawberry two sex forms, pistillate and hermaphrodite, are recognized. Although plants of pistillate-flowered varieties are reported to produce stamens occasionally, they have never been observed by the writer to do so. Instead, they produce staminodia, which do not contain even abortive pollen. Staminodia are seen as small white projections surrounding the pistils.

Plants of pistillate varieties commonly set all their flowers. Although plants of hermaphrodite varieties ordinarily produce flowers having both stamens and pistils, some of the flowers of many varieties so not contain stamens. In rare cases also flowers of this form have been produced which lack pistils entirely. (Fig. 1.) Plants of hermaphrodite varieties do not ordinarily set all their flowers; many of the later ones on an inflorescence may be sterile.

There is a marked difference between the fertility of hermaphodite varieties grown to-day and that of those raised 75 years ago (*1*).[2] Varieties grown in 1850 set only 15 to 20 per cent of their flowers; present varieties set on an average about 66 per cent and some set as high as 100 per cent.

Self-sterility and cross-sterility, common in other fruits of the rose family, have not been found in the cultivated strawberry. Pistil sterility of hermaphrodite varieties is the only important type of sterility in this fruit. It is and always has been one of the outstanding problems in the development of the strawberry. (Fig. 2.)

Valleau (*7*) has shown that pollen abortion is common in cultivated varieties of strawberries. Ordinarily this is of little importance commercially among cultivated varieties. In the Glen Mary and Progressive varities, however, lack of pollination, resulting from the scarcity of the good pollen grains, may cause some "nubbins." In all cases thus far observed pollen grains similar in appearance to those of a good species have been found to fecundate fertile pistils of any variety in the same chromosome group.

RELATION OF SEX TYPES TO SPECIES

Longley (*3*) has recently pointed out that the 7-chromosome species, *Fragaria vesca*, *F. nilgerrensis*, and allied forms are characterized by the production of only hermaphrodite flowers, all of which

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[2] Reference is made by number (italic) to "Literature cited," p. 411.

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set. The 21-chromosome species, *F. elatior*, and the 28-chromosome species, *F. chiloensis*, *F. virginiana*, and allied forms have a variety of sex-flower types. Some seedlings in each 28-chromosome species studied bear pistillate and others hermaphrodite flowers, the hermaphrodite-flowered forms exhibiting a series of sex types ranging from those setting all flowers to those setting none.

The cultivated varieties of Europe and America are supposed to have descended in part at least from plants of *Fragaria chiloensis* taken to Europe in 1714 by Frezier. Wilson Popenoe has recently

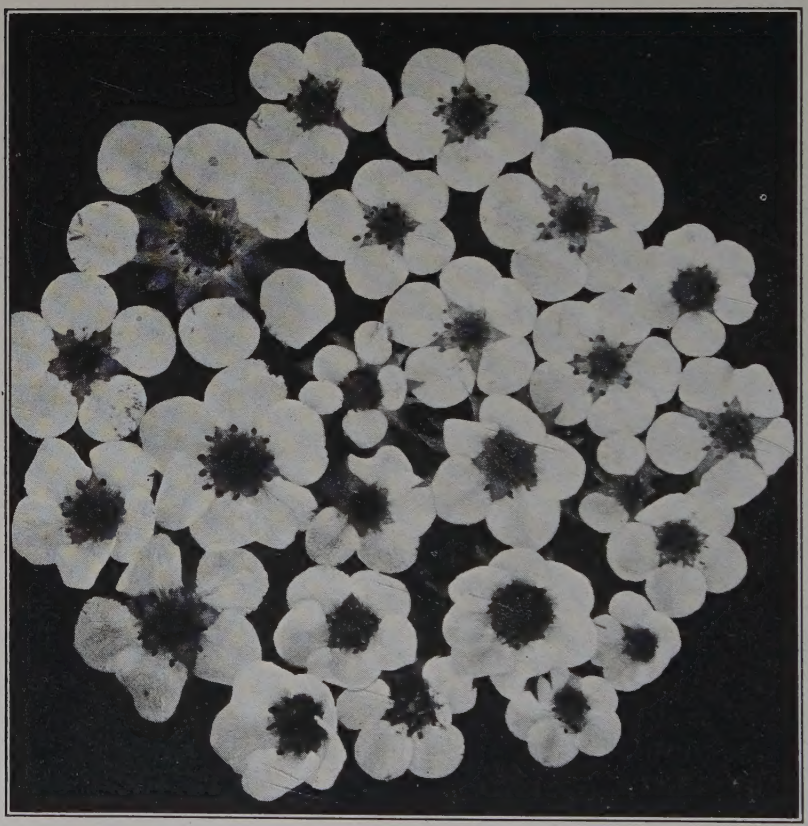

FIG. 1.—Flower types of the Howard 17 strawberry. Flowers with all parts present, some lacking part or all of the stamens, and one lacking pistils, are shown

reintroduced what he regards as the same variety. It is hermaphrodite-flowered and under conditions at Glenn Dale, Md., its flowers are mostly sterile. (Fig. 3.) Of several hundred crosses of *F. chiloensis* with cultivated varieties at Glenn Dale, most showed similar sterility. Though Duchense and many later writers refer to Frezier's plant as pistillate-flowered, Popenoe has stated that he has never seen a pistillate variety of this species under cultivation in any part of South America. All the hermaphrodite seedlings of *F. chiloensis* from the Pacific Coast recently placed under cultivation at the Bell Horticultural Field Station at Glenn Dale, Md. were nearly or

FIG. 2.—Seedlings of *Fragaria virginiana* No. 27 (pistillate) × Marshall; that to the left (pistillate) has set all flowers; that to the right (hermaphrodite) has set none. Photograph taken June 25, 1924

FIG. 3.—The Chilean strawberry brought to this country by Wilson Popenoe. It has long been grown in South America and is supposed to be the same variety as that taken to France by Frezier in 1714. Note that four fruits have set seeds and two others have set a few seeds. Thirteen flowers were sterile

entirely sterile. Pistillate seedlings from the same source set all their flowers. Examination of large numbers of *F. chiloensis* near the mouth of the Columbia River on both the Oregon and Washington coasts in 1926 showed the same condition. The pistillate plants set all their flowers. Most of the hermaphrodite ones were sterile although some bore more or less fruit.

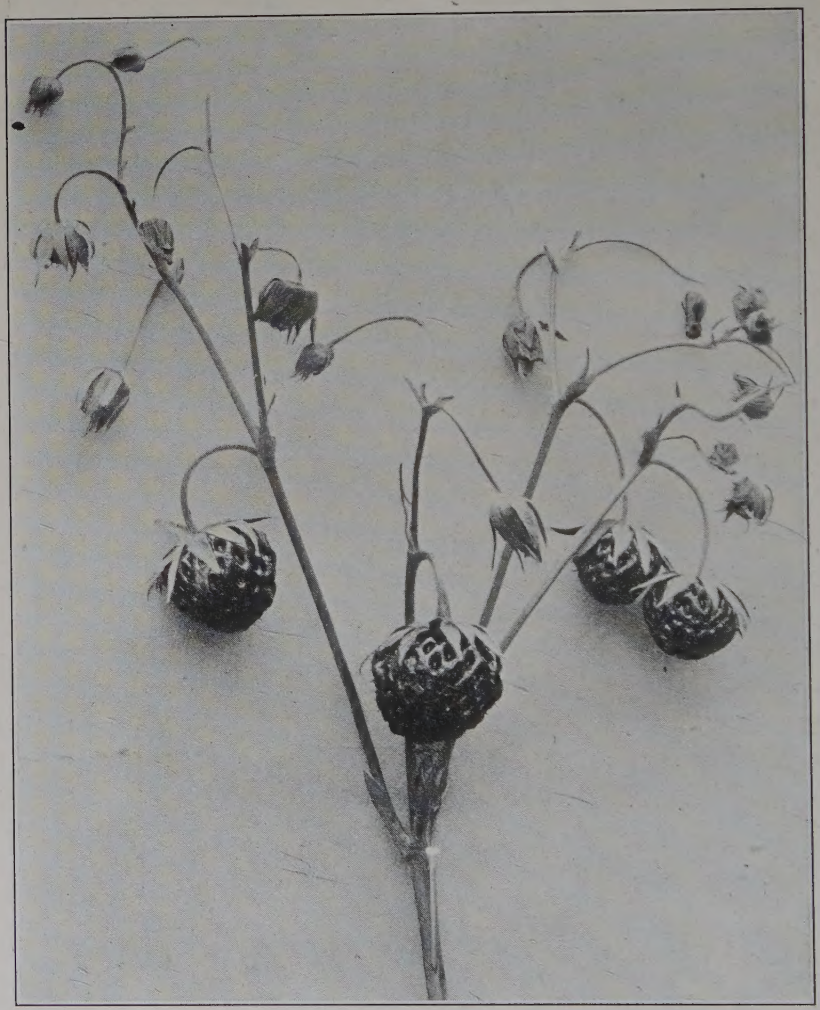

FIG. 4.—Fruit cluster of Little Scarlet, a variety of strawberry long grown in Europe for jam. It is probably an American selection of the wild *Fragaria virginiana*. Five flowers out of nineteen set fruit. On heavy soils at Geneva, N. Y., a much larger percentage sets fruit. Photograph taken June 12, 1924

To obtain the European strawberry of to-day, selections of *Fragaria virginiana* were crossed by the early breeders with *F. chiloensis*. It has been possible to procure from England the Little Scarlet variety, one of these early selections. At Glenn Dale, Md., this variety shows sterility comparable to the Chilean variety introduced by Popenoe. (Fig. 4.) Crosses of it with cultivated varieties are

apparently even more sterile than similar crosses with the Chilean. Valleau (*7*) reports that in the wild, a large part of the hermaphrodite forms of *F. virginiana* are sterile while pistillate varieties set all their flowers. *F. chiloensis* and *F. virginiana*, from which cultivated varieties are chiefly or wholly derived, apparently exhibit similar sex types and sterility.

CORRELATION OF STERILITY AND STAMEN PRODUCTION

Valleau (*7*) points out that pistillate flowers occur on hermaphrodite varieties and that when they occur on hermaphrodite-flowered seedlings which usually are entirely sterile, such pistillate flowers set fruit. Records previously published (*1*) show that the pistillate flowers found on hermaphrodite varieties are commonly the first flowers to open on an inflorescence; that is, they are the primary and secondary flowers. The first flowers to open, the primary and secondary ones, are also most likely to set on hermaphrodite varieties. All or commonly all pistillate flowers set fruit, and sterility tends to appear only when stamens are produced.

PISTILLATE FLOWERS ON HERMAPHRODITE VARIETIES

The frequency with which pistillate flowers are found on hermaphrodite varieties has been shown by the writer. Occasionally when cool weather prevails and flowering is delayed these first flowers are not pollinated and the extent of the occurrence of such pistillate flowers assumes some importance.

The occurrence of pistillate flowers on hermaphrodite varieties varies in different years. In 1925, for example, 28 varieties at Glenn Dale, Md., showed pistillate flowers on which none were noted in 1926. Fruit-bud studies (*3*) indicate that in the primary flowers at least, stamens develop in the fall nearly to the pollen-mother-cell stage, in all but the latest formed plants in northern States. Fall conditions affect considerably the development of the sex organs in certain varieties, inhibiting the formation of anthers in many of the first flowers to differentiate.

INTERMEDIATES BETWEEN HERMAPHRODITE AND PISTILLATE VARIETIES

Valleau (*7*) has reported intergrades in hermaphrodite varieties from those setting all or nearly all of their flowers to those setting no flowers. These intergrades are in reality males having pistils which are not functional. Heretofore, no instances have been noted in which intergrades between hermaphrodite and pistillate varieties have occurred. Two such intergrades have apparently been found among the selections resulting from the practical breeding work of the Bureau of Plant Industry at Glenn Dale, Md. The first is No. 503, a selection of Ettersburg 445 × Howard 17. A count on this selection, May 11, 1926, early in the blossoming season, showed 38 pistillate flowers, 54 with all stamens abortive, and 74 with one or more good stamens. On May 15 the same plants showed 23 pistillate flowers, 20 with abortive stamens, and 84 with one or more good stamens.

The other selection, No. 799, Portia × Kalicene, had on May 11 only 4 pistillate flowers, 69 with abortive stamens, and 39 with one or

more good stamens. Of these, 29 primary flowers had abortive stamens and 6 had some good stamens. Three secondary flowers were pistillate, 32 had all abortive stamens, and 24 some good stamens. One tertiary flower was pistillate, 8 had abortive stamens, and 9 some

FIG. 5—Selection No. 799, Portia × Kalicene, which is apparently an intermediate between a pistillate and a hermaphrodite variety. Some flowers are pistillate, others have abortive stems and still others have good stamens. Photograph taken May 14, 1926

good stamens. Although no counts were made, it was observed that most of the last flowers to open had good stamens It is possible that these two selections, Nos. 503 and 799, represent intermediate stages between pistillate and hermaphrodite varieties. (Fig. 5.)

Attention should also be called to a hermaphrodite variety, Rockhill, which, under conditions at Glenn Dale, Md., sets nearly all of its flowers. A count of 20 plants showed an average of 37.2 fruits set, 2.9 flowers not set, and 6.4 flowers, buds, or missing. The set of fruit obtained in the Rockhill compares favorably with that of pistillate varieties. Near by, Sample, a pistillate variety, set an average of 8.6 fruits, 2.3 did not set, and 0.3 were flowers, buds, or missing. Selections of crosses of Rockhill with other varieties show a remarkably high percentage of flowers that set. They also show many pistillate flowers and flowers containing abortive stamens. Whether such a variety should be listed as an intermediate between a pistillate and a hermaphrodite variety is not yet clear.

CHANGE OF SEX

One variety, Ettersburg 121, has, on some soils in Oregon, been reported as the most productive sort, while on other soils a large percentage of its flowers have been sterile and it has been so unproductive as to be unprofitable. After a careful survey, Schuster (*6*), of the Oregon Experiment Station, found it to be most productive on rather heavy soils and least productive on sandy soils. When grown on sandy soil at Glenn Dale, Md., rarely does 1 flower in 50 of the Ettersburg 121 set fruit. The writer's attention has been called by W. A. Taylor, of the Bureau of Plant Industry, to a similar difference in productiveness in the Cumberland Triumph grown some 30 years ago, which was productive on the heavier black soils in the eastern part of the United States but was unproductive on light soils.

C. C. Georgeson, Director of the Alaska Agricultural Experiment Station, has reported (*2*) a change in fertility in the beach strawberry, *Fragaria chiloensis*, which was unproductive when set in good garden soils but when transplanted to sterile volcanic soils became productive. Little Scarlet sets few flowers on sandy soils at Glenn Dale, Md., but on clay soils at Geneva N. Y., it sets most of its flowers. These observations indicate that sterility in the strawberry may be greatly influenced by the soil type. Just what influence the soil does have, however, is difficult to determine.

Valleau (*7*) also cited instances of changes in the sex type of varieties. For example, plants of the Glenville variety which set fruit only occasionally when grown in the greenhouse set over 50 per cent of its flowers the following summer.

European varieties, when grown at Glenn Dale, Md., exhibit sterility to a marked degree. Few of the scores of varieties introduced in the past few years set more than 1 to 3 flowers to each inflorescence. (Fig. 6.) In this case the length of day rather than soil type is the most marked environmental difference, the days being much longer in Europe during most of the growing period than in the United States. Whether difference in length of day or some other influence at the time of fruit-bud formation is actually the cause of the difference in sterility is of course only speculative.

Records have previously been published showing the extent of sterility in cultivated varieties (*1*). Additional records are given in the accompanying tables, as follows: Table 1 shows the average number of fruits and of flowers not setting on 20 hermaphrodite varieties for which records were obtained in 1925 and 1926; Table 2 gives the same data for other varieties.

TABLE 1.—*Average number of fruits and of flowers not setting per plant of 20 varieties of strawberries in 1925 and 1926, Glenn Dale, Md. The data for 1925 are averages of 10 plants, and for 1926 of 30 plants, except as noted*

Variety	1925		1926		Remarks
	Fruits	Flowers not set	Fruits	Flowers not set	
Americus	7.4	7.2	7.2	8.7	
Big Wonder	6.6	23.4	4.3	18.8	Average 20 plants, 1925.
Brandywine	17.1	4.4	10.2	13.0	
Campbell	23.1	9.3	17.7	12.6	
Clark	6.0	9.2	2.3	3.5	
Ekey	9.2	18.2	5.0	13.3	
Excelsior	10.9	1.8	5.7	2.3	Average 25 plants, 1925.
Freemont Williams	5.6	4.5	6.6	4.9	
Glen Mary	11.1	4.1	11.6	4.3	
Gold Mine	15.2	1.0	9.4	2.7	
Howard 17	16.4	2.7	6.7	1.8	Average 36 plants, 1925; 305 plants, 1926.
Judith	13.8	6.2	6.2	3.0	
Lady Corneille	12.6	9.7	6.1	4.4	
Late Stevens	6.1	2.5	4.4	4.8	
Marvel	16.1	7.0	11.2	3.8	
Mascot	10.7	8.4	6.0	3.0	
McAlpine	13.9	11.0	4.7	4.8	
Ozark	10.3	1.0	12.8	1.0	
Pearl	13.0	1.2	19.4	.5	
Progressive (Champion)	16.0	1.8	14.7	1.1	
Average	12.6	6.7	8.6	5.6	
Percentage of flowers not set		36		39	

TABLE 2.—*Average number of fruits and of flowers not setting per plant of strawberry varieties in 1925 and 1926, Glenn Dale, Md. The data for 1925 are averages of 10 plants, and for 1926 of 30 plants, except as noted*

Variety	1925			1926			Remarks
	Fruits	Flowers not set	Others	Fruits	Flowers not set	Others	
Abington	19.3	8.0	0.9				
Ananas de Guemeice (P.)				9.3	0	1.6	
Aroma				3.7	3.1	−.8	Average 100 plants.
Plants rooting by July 15, 1925.				6.0	3.9	−.1	Average 19 plants.
Plants rooting July 15–Aug. 1, 1925.				4.5	3.4	.2	Average 19 plants.
Plants rooting Aug. 1–Sept. 9, 1925.				2.7	2.8	.0	Average 62 plants.
Benson	10.5	11.0	1.3				
Big Late (P)	11.2	.9	3.6				
Bun	22.7	7.0	6.1				
Burrill				5.4	8.4	−1.9	
Chesapeake	12.4	.3	2.4				Average 146 plants.
Cooper	13.1	3.9	1.8				
Delicious	13.6	10.7	2.5				
Doctor Hogg	15.4	1.6	1.5				
Dunlap (potted)				10.7	9.3		Average 69 plants.
Dunlap (in field)				4.7	6.9	.7	Average 307 plants.
Plants rooting by July 15, 1925.				10.1	9.2	2.1	Average 46 plants.
Plants rooting July 15–Aug. 1, 1925.				6.1	8.7	1.0	Average 84 plants.
Plants rooting Aug. 1–Sept. 9, 1925.				2.5	5.3	.2	Average 177 plants.
Eaton				8.2	1.8	.7	
Ettersburg No. 80	11.6	10.7	2.5				
Ettersburg No. 121	.2	17.3	10.7				
Ettersburg No. 121				1.9	5.0	.3	Average 61 trusses.
Ettersburg No. 445 (P)	10.2	0	2.9				
Fendall (P)	20.3	.1	3.0				
Gardners No. 999	9.0	14.7	1.1				
Haverland (P)	33.9	2.9	2.3				
Heflin	13.6	13.8	2.2				

TABLE 2.—*Average number of fruits and of flowers not setting per plant of strawberry varieties in 1925 and 1926, Glenn Dale, Md. The data for 1925 are averages of 10 plants, and for 1926 of 30 plants, except as noted*—Continued

Variety	1925			1926			Remarks
	Fruits	Flowers not set	Others	Fruits	Flowers not set	Others	
Howard 17				6.7	1.0	3.0	Average 305 plants.
Plants rooting by July 15, 1925.				9.6	.6	2.9	Average 59 plants.
Plants rooting July 15–Aug. 1, 1925.				9.5	.8	2.3	Average 76 plants.
Plants rooting Aug. 1–Sept. 9, 1925.				4.5	1.3	1.6	Average 170 plants.
Howard 25 (P)	45.2	2.9	2.2				
Kalicene				8.2	1.1	.4	Average 31 trusses.
Kelloggs Prize (P)	19.9	.5	2.7	12.4	.9	.5	
Klondike				3.8	.7	.8	Average 303 plants.
Plants rooting by July 15, 1925.				5.2	.3	.8	Average 80 plants.
Plants rooting July 15–Aug. 1, 1925.				4.7	.7	.9	Average 85 plants.
Plants rooting Aug. 1–Sept. 9, 1925.				2.3	.9	.7	Average 138 plants.
La Constante	3.0	39.8	1.9				
La Perle	9.1	.8	2.6				
Lupton	5.9	0	.1				
Michel	10.4	3.2	2.1				Average 25 plants.
Missionary				4.2	2.6	.6	Average 488 plants.
Plants rooting by July 15, 1925.				5.2	2.8	1.1	Average 143 plants.
Plants rooting July 15–Aug. 1, 1925.				4.5	2.8	.7	Average 142 plants.
Plants rooting Aug. 1–Sept. 9, 1925.				3.3	2.3	.2	Average 203 plants.
New York	6.8	8.7	1.8				
Orem	7.1	7.1	1.2				
Portia (P)				8.6	0	.3	Average 100 plants.
Rockhill				37.2	2.9	6.4	Average 20 plants.
Sample				8.6	2.3	.3	Average 100 plants.
Plants rooting by July 15, 1925.				13.3	2.3	.7	Average 23 plants.
Plants rooting July 15–Aug. 1, 1925.				9.1	2.1	.2	Average 27 plants.
Plants rooting Aug. 1–Sept. 9, 1925.				6.2	2.5	.2	Average 50 plants.
Shropshire	8.6	1.4	1.2				
Success	15.5	1.9	2.4				
Tennessee				8.4	4.3	2.6	Average 29 plants.
The Queen	4.4	3.5	1.5				
Van Fleet No. 125				6.2	3.1	1.0	Average 100 plants.
Van Fleet No. 125 (with stable manure mulch).				8.8	3.2	1.5	Average 100 plants.
Vanguard				5.8	2.1	.5	
Vineland No. 19322				6.0	.7	.4	
Warfield (P)	31.2	4.3	2.6	13.1	2.9	.3	
White Pineapple	1.2	18.4	.2				
Average 7 pistillate varieties.	31.7	1.7	2.8				
Average 21 hermaphrodite varieties.	10.2	8.8	2.2				

The average number of flowers not setting in 20 varieties of strawberries, as shown in Table 1, was 6.7, or 36 per cent in 1925, as compared to 5.6, or 39 per cent, in 1926—hardly a significant difference. For all varieties the correspondence for the two years is remarkable. Attention is called, however, to certain exceptions. Thus the Brandywine showed a marked change, producing 17.1 fruits and 4.4 flowers not set in 1925 and 10.2 fruits and 13.0 flowers not set in 1926. Late Stevens also showed a marked difference. In 1925 the number of flowers not setting in this variety was less than one-half the number of fruits not setting, as contrasted with more

flowers than fruits not setting in 1926. Both Brandywine and Late Stevens showed a decided increase in sterility in 1926 over 1925.

The close agreement in both years in such varieties as Big Wonder, which showed a relatively large number of flowers not setting; in Americus with almost an equal number of flowers not setting and of fruits; and in Gold Mine, Howard 17, Ozark, and Pearl, which showed few flowers not setting, is noteworthy.

FIG. 6.—A fruit stem of Utility, an English strawberry, showing the primary and two secondary berries set; the rest did not set

At the bottom of Table 2 is given the average of the 7 pistillate and 21 hermaphrodite varieties on which records were obtained in 1925. Pistillate varieties produced an average of 1.7 flowers and hermaphrodite varieties 8.8 flowers, which did not set. The difference between the number of pistillate and hermaphrodite varieties not setting flowers is 6.1, or 37 per cent. It is probable that this difference represents the actual number of sterile flowers which would not set under any conditions.

EFFECT OF FALL CONDITIONS ON STERILITY

In the northern and northeastern part of the United States, the fruit buds of the strawberry differentiate in the autumn. The first traces of fruit buds were found by Ruef and Richey (*5*) in Iowa by the middle of September. Fruit buds develop rapidly and show well-developed pistils and stamens before winter. In some varieties, anther development in the primary and secondary flowers proceeds nearly to the pollen-mother-cell stage before winter.

Ventilated boxes constructed to exclude all light have been placed over dormant plants in the field at Glenn Dale, Md., and kept over them until the blossoming season. The strawberries came into flower in the dark, but in no case was there any apparent development of stamens or petals. Sepals developed to a limited extent

FIG. 7.—The Howard 17 variety, brought into flower in late winter, showing 19 flowers lacking good stamens, 6 of which also lack developed petals. Even the sepals are much smaller than usual. Photograph taken April 11, 1925

only. Other dormant strawberry plants grown in dark constant-temperature chambers behaved in the same way. Light seems to be necessary for the development at least of stamens and petals. Figure 7 shows a plant brought into flower in the short days of winter. Many of the flowers did not produce any good stamens and some did not produce any petals. Usually, under such conditions, the pistils were functional and set fruit although in some cases this did not seem to be the case. It would appear that pistil development proceeded relatively farther than stamen development in the fall.

Gardner in Missouri found no change in the number of fruits on plants of the Dunlap variety following the application of nutrients in the spring. In Michigan, Loree (*4*) increased the set of fruit on plants of the Dunlap variety grown in a very light sand by the application of nitrogen in the spring of the fruiting year. Unfertilized plants set 22.7 per cent of their blossoms, while plants fertilized with

nitrate of soda just before blossoming set 40 per cent. Set of fruit, however, may not be an index of pistil sterility in his experiments. Plants receiving spring applications of nitrogen make a vigorous growth and thus supply ample water and food to their flowers, which weak plants are less able to do. Even though the pistils of the flowers of the weaker plants in Loree's experiment may have been fertile they may not have been supplied with the essentials for further development. A similar test of a pistillate variety might perhaps give similar results even though all the pistils of the variety were fertile. At Glenn Dale, Md., no spring treatment given seems to have affected the proportion of sterile flowers in the spring.

Frost often kills the pistils of the first flowers on inflorescences of varieties which commonly set only these first flowers. When this occurs no later flowers appear to set. The pistils of the first flowers may be killed when the buds are very small, but in no case has any change in the setting been observed. In a seedling (*Fragaria platypetala* × Klondike), which commonly set only the first flowers on an inflorescence, all the primary flowers were picked off before they opened. No increase in the set of later flowers was obtained. Under most conditions pistil sterility seems to be determined in the fall.

A hermaphrodite selection of supposedly pure *Fragaria virginiana* collected by D. N. Shoemaker in the mountains of North Carolina is shown in Figure 8. Its basal truss, which had 6 flowers not set and 19 fruits set, is shown in Figure 9. Figure 10 shows the three higher trusses which produced 20 fruits and also 13 flowers which did not set. As the inflorescence of the strawberry is terminal, new growing points must form before other fruit buds can develop. The basal truss shown is the center one and developed first; new growing points were then laid down, which later formed fruit buds; but on these later-formed inflorescences a slightly larger percentage of the flowers were sterile. Figure 11 shows a potted plant of the Dunlap with a basal and high-branching truss, the first having 5 fruits and 2 sterile flowers and the latter 5 fruits and 5 sterile flowers. Records taken on 31 potted plants of this variety having two or more trusses gave 46 per cent sterile on the earlier trusses and 62 per cent sterile on the later ones.

Examination of other cultivated varieties reveals the same condition as in the Dunlap; the later-formed trusses show greater sterility than those formed earlier. Figure 12 shows a crown of the Howard 17 variety with three trusses, the center one of which set 5 fruits one of which was frosted. The other trusses produced 5 fruits and 4 sterile flowers. It is evident that the later-formed fruit buds exhibit a greater percentage of sterility than do those formed earlier. Whether this is due to climatic, nutritional, or other conditions at the time of fruit-bud formation is not clear.

Ruef and Richey (*5*) reported that the earlier-rooting runner plants formed fruit buds first and that these buds developed to a greater degree in the fall than did those formed later. Table 2 summarizes a record of the number of fruits and sterile flowers produced in 1926 on strawberry plants of leading standard varieties, the runners of which were rooted on different dates in 1925. Thus, on May 24,

FIG. 8.—One plant of selection No. 13 of *Fragaria virginiana*, which has produced several fruit clusters. The earlier flowers set; many of the later ones did not

FIG. 9.—The basal truss of the plant shown in Figure 8. Nineteen fruits set and 6 flowers did not. Photograph taken June 12, 1924

FIG. 10.—Three later-formed trusses of the plant shown in Figure 8. To the right are shown 8 fruits and 5 flowers not set; in the center 6 fruits, 1 flower, and 3 flowers not set; to the left 6 fruits and 5 flowers not set; a total of 20 fruits, 1 flower, and 13 flowers not set

FIG. 11.—Dunlap plant with basal and high-branching clusters. The basal cluster has 5 fruits and 2 sterile flowers; the high cluster 5 fruits and 5 sterile flowers. The basal cluster has also earlier-maturing fruit

1926, counts were made on 303 plants of the Klondike, the most important commercial variety in America, which were rooted on different dates the previous year. Eighty plants, rooted on or before July 15, produced 418 fruits, 21 flowers not set, and 65 others (average 5.2, 0.3, 0.8). Eighty-five plants, rooted between July 15 and August 1, produced 400 fruits, 59 flowers not set, and 80 others (average 4.7, 0.7, 0.9); 138 plants rooted August 1 to September 9 produced 322 fruits, 129 flowers not set, and 102 others (average 2.3, 0.9, 0.7).

FIG. 12.—Howard 17 strawberry plant with 3 fruit clusters. The center was the terminal and formed 5 flowers, one of which was frosted. Later a new growing point developed on each side and a terminal inflorescence formed on each point. On that to the left 2 fruits and 3 sterile flowers, and on that to the right 3 fruits and 1 sterile flower developed

Of the five hermaphrodite sorts, Klondike, Howard 17, Aroma, Dunlap, and Missionary, the average was 60 per cent fruits and 28 per cent flowers not set for the plants rooted earliest; 58 per cent fruits and 32 per cent flowers not set for late July plants; and 51 per

cent fruits and 41 per cent flowers not set for plants rooted in August and early September. In every variety an increase in the percentage of flowers not setting in the later-rooted plants is evident, although the number and percentage of flowers not setting differs with varieties. (Figs. 13 and 14.)

This increase in unfruitful flowers may be attributed to the time of formation of fruit buds, the later-rooting plants forming fruit buds last, or to the relative vigor and food supply of the plants on which

FIG. 13.—Plant of Howard 17 strawberry, rooted in July, which produced 12 fruits and 1 sterile flower

they were borne. If time of fruit-bud formation is the important factor then it may be assumed that the influence of one or more climatic conditions effective at the time of fruit-bud formation directly or indirectly determines the extent of sterility.

From a comparison of the extent of sterility during different years it is evident that factors such as sunlight, temperature, evaporating power of the air, water-supplying power of the soil, length of growing season, or other similar factors were sufficiently different during the fall periods to bring about a change in the degree of sterility in some varieties.

SUMMARY

The two species, *Fragaria chiloensis* and *F. virginiana*, from which cultivated strawberries have largely or entirely developed, have the same chromosome number, and exhibit the same pistillate and hermaphrodite flowered sex types; the latter type shows great diversity from males possessing no functional pistils to those setting many of their flowers.

Under the conditions which prevail at Glenn Dale, Md., plants of the particular varieties of *Fragaria chiloensis* and of *F. virginiana* from which modern varieties may have been chiefly derived are largely sterile.

Two selections are reported as intermediates between hermaphrodite and pistillate forms, the first representatives of such a group yet reported. A hermaphrodite variety, the Rockhill, is reported as behaving, in the setting of its flowers, more like a pistillate than a perfect-flowered variety.

Evidence that sex expression in hermaphrodite varieties is changed by soil conditions has been presented by others and apparently is confirmed. Records covering the setting of flowers and fruit of 20 varieties for both 1925 and 1926 and of many other varieties for one of these years are presented. They show a remarkable correspondence in percentage of sterility in varieties for the two years.

FIG. 14.—Howard 17 strawberry plant, rooted in September, 1925, which produced 8 fruits and 3 sterile flowers

When the floral parts abort or do not develop because of unfavorable conditions the stamens are the first to be affected. Under more extreme conditions petals are lost, sepals next, while pistils are the least likely to be affected.

Although it may affect the actual set of fruit, spring treatment appears not to affect the number of sterile flowers.

The earlier formed trusses and the earlier rooted plants of the previous season appear to have less sterility than those formed or rooted later.

The character of the fall season is considered one of the important causes of fertility and sterility in this fruit.

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